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ABSTRACT

This study features a program evaluation of a policy that allows gifted 8th grade mathematics students to take algebra. The study is longitudinal and looks at the effects of taking algebra in the 8th grade and the subsequent four years of mathematics in high school. Among the specific research questions in the study are: (1) To what degree do students in 8th grade algebra progress through upper level mathematics after early entry? (2) To what extent do some of these accelerated students have negative experiences? and (3) Does the elementary school mathematics curriculum (self pacing versus traditional) affect the mathematics profile for 8th grade algebra and subsequent mathematics courses? The study concludes that the policy of accelerating students in mathematics at this particular school had a negative impact for many of those students. (MM)

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EIGHTH GRADE ALGEBRA ACCELERATION: A CASE STUDY OF LONGITUDINAL EFFECTS THROUGH THE HIGH SCHOOL PIPELINE

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Statement of the Problem

One of the two elementary schools in the North Central School Corporation decided to institute Self-Pacing Math (Mastery Learning) in their mathematics curriculum. Gifted math students were given a workbook and told to go at their own pace in working the problems. Students were to use the teacher as a tester and grader as well as a resource to help work and understand difficult problems. Many of the students saw the class as a game or a race and would go as fast as they could as far as they could in the workbook to stay ahead of the others in the class. This created a competitive atmosphere among the students. Ultimately, many of the students were very far along in their math by the time they passed to the sixth grade in the middle school.

The other elementary school used the traditional method of teaching math. The middle school principal was left with the problem of finding a math curriculum for those gifted math students who were in the self-pacing class and the gifted math students from the traditional math program. The principal could have the students take the regular middle school math, which many had completed in their "math competition," he could introduce new math concepts normally introduced at the high school level, or he could chose to offer a high school math class. The principal chose to give them as much middle school math as possible in the sixth and seventh grade and then asked one of his math teachers to teach them algebra in the eighth grade. (As middle school is characterized by status and peer pressure, the question is raised as to how many parents requested that their child be allowed to take algebra in the eighth grade because their children's friends were in the class.)

Jean Piaget (1971), a cognitive learning psychologist, talked about a "learning

period" (p. 307), and Lev Semenich Vygotsky (1962), another cognitive learning psychologist who simultaneously discovered the "zone of proximal development" (p. 103), knew that children were only able to learn when they developed to a "ready" stage in their life. While educator motives are to continue to push students to higher ground, in fact, are they being pushed ahead of their "zone of proximal development" or "learning period" into a situation where they feel overwhelmed and discouraged with math?

As a high school counselor for sixteen years, the senior author noticed that many times the best fifth year math students in high school were those who took the normal math curriculum by taking Algebra I in the ninth grade, then Algebra II and Geometry in the tenth grade. It also appeared that those who were accelerated would be prone to drop out of the math program early. (Students can be pushed ahead until they feel that they are failing to live up to their own expectations.) After all, isn't one marker of success as educators to see the better students become "A" students? On the other hand many students are not sufficiently challenged to realize their potential. Finding the optimum level of academic push is crucial--but never easy, and all too seldom informed by empirical evidence.

Background

Algebra seems to be the "gateway" to a higher level of mathematics (Shakrani, 1996), particularly calculus, a fifth year math class, which Elizabeth Useem (1990, p. 26) calls the "capstone" course of an "accelerated" math sequence. Useem also noted that calculus is a "gateway" course in more than half of the college majors and that approximately 35% fail and drop the course in college. According to Useem (p. 24), high school math teachers argue that calculus is more ably taught at the high school level

because of smaller classes, more frequent homework graded and assigned, and good teachers instructing the course. Regardless of where it is learned, most of the careers that require professional degrees from colleges require an extensive amount of mathematics.

In order to help students get a head start on these high school math courses, many middle school principals have introduced algebra in the eighth grade (Shakrani, 1996). The National Council of Teachers of Mathematics feels that all eighth grade students should be taught a wide range of mathematics topics, which includes algebra (Shakrani). A 1992 survey done by the National Assessment of Educational Progress indicated that nationally 20% of eighth graders took algebra (NCES, 1992). Jefferson County (KY) Public Schools (1997) in their pamphlet "A Promise to Our Youth--A Guarantee to Our Community" advertised that middle school will increase the number of students successfully completing higher-level coursework, i.e., algebra and applied physics" (p. 1). The U.S. Department of Education (1997) objective 2.3 in the Strategic Plan states: "Every eighth grader masters challenging mathematics, including the foundations of algebra and geometry." There is a trend in the middle schools and junior highs in the nation for students to take algebra before high school. When looking at this data, it is important to remember that if nationally 20% of the eighth graders took algebra, then the ninth graders who might be compared with them would likely be those who were not allowed to take algebra in the eighth grade and therefore not the most gifted math group.

Purpose of the Study

There are several issues that could be examined in this study: students' recollections of their accelerated math experiences; various ways of screening students; or even the fact that in Indiana, middle school students only have a forty minute period in

an eight period day compared to high school where there are at least fifty-two minutes in a seven period day. (The middle school has shorter periods to offer students a diverse experience rather than a narrow one. The school year is filled with field trips, school assemblies and other experiences, which take the student away from the classroom.) In many cases, a middle school math teacher who may not be accustomed to teaching high school algebra teaches the eighth grade algebra class. Middle school students are not always ready to devote the study time necessary to gain command of material. (In talking with the upper elementary school principal, Dr. Uhl, on 3/19/98, she said that each year she must deal with parents of those sixth grade students not chosen for pre-algebra in the seventh grade.)

However, this study is a longitudinal evaluation, taken from one of the first classes at North Harrison Middle School to take algebra in the eighth grade. This "chart study" (Richard Miller, lecture, 9/17/97) examines the effects of eighth graders taking what has typically (in the past) been a high school subject taught by high school teachers: algebra. The study is in effect a program evaluation of the policy that allows gifted eighth grade math students to take algebra. (The college preparatory math curriculum at North Harrison High School before this policy was instituted was the sequence of algebra in the ninth grade, geometry in the tenth grade, advanced algebra in the eleventh grade, and trigonometry in the first semester with analytic geometry in the second semester of the twelfth grade. If a student wished to make room for the fifth year of math, pre-calculus, he/she would take advanced algebra and geometry at the same time in the tenth grade. All pre-calculus students up to this time were "doubling up" in the tenth grade.)

Specifically in this study, the authors investigate the effects of taking algebra in

the eighth grade and the subsequent four years of math in high school. While allowing gifted eighth grade math students to take algebra seems to be a positive thing to do for students and for the math department, there may be a negative side if students become discouraged in their ability to handle the higher levels of mathematics in later years. Middle school is characterized by exploration of different subjects (which shortens the periods), numerous field trips, and school convocations. Does pushing too early turn students off to math, the subject they feel comfortable with in the eighth grade? This study follows the graduating class of 1992 over the course of five years; what is the impact on these students throughout the math pipeline of taking algebra in the eighth grade? The data should help in assessing whether this policy is good for these talented eighth graders who are likely to matriculate to college.

Perspectives on Policy

Policy is a term that is as "broad as it is long." There is ambiguity in the term that brings to mind different definitions based on the person's experience. In an attempt to condense the meaning of policy, Guba's (1984) framework gives a point of reference and commonality. Guba describes eight different policy definitions grouped into three categories. Policies one through four talk about policy-in- intention or descriptions of policy, policies five through seven talk about policy-in-implementation or activities used to implement the policy, and policy eight, the policy-in-experience or what the client experiences because of the policy (p. 65).

This paper examines the current policy of gifted eighth graders taking algebra. This policy is informal because it does not specify who can take algebra in the eighth grade or how students are chosen. It appears that those students who finish self-pacing

math from one elementary school are eligible as are those receiving teacher recommendations for the students from the other elementary. There was no placement exam given to seventh graders before placement into eighth grade algebra.

This policy could be Guba's (1984) first policy, which talks about goals or intents. The policy was implemented for a purpose. Gifted eighth graders may take algebra rather than review math concepts and get a head start on math in high school. Here the analysis would examine by whom and why the policy was formulated, as well as the degree of understanding currently by the board of education. Guba's fifth policy focusing on the practices of the eighth grade algebra teachers and comparing them to the high school algebra teachers is a further possibility. Guba's eighth policy perspective would examine what the students are experiencing while taking an advanced class.

However, for the purpose of this study, Guba's (1984) seventh policy, which looks at policy as the output of the entire policy-making system, is clearly relevant. Does the policy accomplish its goals or are there latent unintended effects for the students taking this accelerated class? Thus, this study, through Guba's lens number seven investigates the effects on the North Harrison High School class of 1992 for those students who took algebra in the eighth grade, consistent with Smith's (1996, p. 141) statement "...thus far there is little existing empirical evidence to either support or refute claims of improved attainment for students who have early access to algebra."

The Politics of Math

This policy was develo[illegible] because of a problem. The self-pacing math curriculum initiated at the elem[illegible]ary schools created a situation where a large number of the students coming to the middle school had already completed much if not all of their

middle school math. A decision was needed to resolve the situation. What were these gifted math students going to take to avoid a repeat of what they had learned in elementary school? "In recent years, because of changing state and college requirements, students in high schools have been required to take more advanced mathematics, foreign language, and science courses. To make this possible, various courses once reserved for freshman and sophomore years are now taken in the eighth grade" (Belli & Gatewood, 1987, p. 441).

Nationally the Third International Mathematics and Science study (1996) states, "U.S. eighth graders score below average in mathematics achievement …compared to the 41 nations in the TIMMS assessment" (p. 1). The question has become how to balance the need for a more accelerated math curriculum while ensuring that all students master basic mathematic skills. Kulik and Kulik (1985, p. 409) noted that, "American society usually looks upon the academically gifted as precious resource in times of national threat." They noted that following the Russian launch of Sputnik, the United States immediately began to emphasize math and science for gifted learners. After the space race, however, emphasis switched to the socio-economically disadvantaged and handicapped in the form of special education, Headstart, and Title I.

In the most recent technological era, the push again is emphasizing college and the gifted learner. Currently, a school is looked upon favorably by its public if it is able to offer an accelerated class. It appears it would be the current "politically correct" decision to offer eighth grade algebra. Parents initially look favorably on any program that can help their child get ahead. Unfortunately, principals in a school system are basically given authority to run their schools as they see fit and may make a decision

unilaterally without consent from the other principals in the system. This is a potential problem because once the eighth grade algebra student leaves the middle school, the middle school principal has little time to consider long term student success; subsequently longitudinal program evaluation does not occur.

Research Questions

Some younger students may not be ready for upper level math. Upper level math is not as much a computational skill as it is an abstract thinking capacity. A student may have been good at computing figures but not be able to think in abstract terms or, in terms of Piaget's developmental stages, not yet have moved from concrete operations to abstract reasoning (stage 3 to stage 4). It is possible that if students are not ready, then they may become overwhelmed and discouraged and in fact begin to dislike a class that previously has been stimulating to them. Gifted students have high expectations that when not accomplished, can result in the feelings of failure. This empirical case study can help determine the extent that students in an eighth grade algebra class are actually experiencing success.

Although educators presume that some students benefit by getting a head start on upper level math, this is actually open to study. Guba's (1984) seventh definition, the output of the policy-making system, focuses on just this issue. More particularly, the policy question for Guba 7 is, "What are the collective effects of the behaviors..." (p. 69) of eighth graders taking algebra in the eighth grade? Thus, within the parameters of this larger policy question, these empirical questions apply:

1. To what degree do students in eight grade algebra progress through upper level math after early entry?

a. How many students complete each of the subsequent higher-level math courses up to and through the fifth year math?

b. What is the grade point average (GPA) in each of these math classes?

2. To what extent do some of these accelerated students have negative experiences?

a. How many, and when, do students drop out of the math curriculum?

b. How many students repeat algebra?

c. How many students receive low grades--C or less than a C--in each of the math pipeline courses?

3. Does the elementary school math curriculum (self-pacing vs. traditional) affect the math profile for eighth grade Algebra and subsequent math courses?

a. Number in each course?

b. GPA?

c. Math dropouts and when?

d. Repeat algebra?

e. Less than a "C" in math pipeline courses?

4. To what extent does gender affect student success in early entry to college preparatory mathematics, for factors a-e listed under question #3?

Definition of Terms

Terms of this study include "upper level" math or "math pipeline," meaning those mathematics classes required for entrance in college such as Geometry, Algebra II, Trigonometry, Statistics and Pre-calculus. Pre-calculus is the fifth year math at North Harrison High School (most schools currently offer Calculus as the 5th year math). Most studies found in the literature have calculus as the fifth year math. These are classes that

require "abstract thinking," defined as finding a solution based on a given set of incomplete facts, or in simpler terms, given some information, find the missing information. The term "readiness" originally came from the first nine weeks of the first grade focusing on the preparatory or background skills that students need to read successfully. In this study of mathematics, "readiness" means having the skills needed to succeed at the next upper level math class. "Sorting" is a sociological term depicting a latent intent of schools, which is to begin to separate academic from non- academic students into hierarchical levels. "Accelerating" is another sociological term to describe taking a course before it would normally be taught.

Review of Literature

Mathematics in America

It is interesting that the National Center for Educational Statistics (NCES) began a study with eighth grade students in 1988. This coincides with the dates for the study of eighth graders in algebra in the current study. The NCES study showed that 19% nationally, 16% in Kentucky, 16% in Indiana took algebra in the eighth grade. It also showed that 22% white, 13% black, 12% Hispanic and 42% Asian/Pacific Islander took algebra in the eighth grade. Males took algebra in the eighth grade at a rate of 19% and females at 20% (Shakrani, 1996). For some reason, middle schools and junior highs have dived into this without good research. In the literature on the effects on students taking a pre-college mathematics courses, there is no good evidence regarding offering algebra to eighth grade students. If there is going to be such a small number taking the fifth year math, does pushing students into the math curriculum early help or hinder?

Early Algebra Course Taking

Zalman Usiskin (1987) makes six points to convince the reader that all eighth grade students should take elementary algebra. His first point is that after the sixth grade, there are not many new concepts offered in middle school math and that much of the time in class is spent in review. Usiskin (p. 432) stated, "Students in the junior high school are lulled into a pace whereby they expect to learn a new idea only a few times a year and a new skill only once every couple of weeks." In point two, Usiskin says that eighth grade algebra is successful but only quotes a study by Kulik and Kulik (1984) who did a study on several accelerated programs but did not specifically study eighth grade algebra. Usiskin also points out that an anonymous reviewer of his article reports "...that of 484 eighth graders enrolled in first year algebra, only 116 continued through 12^{th} grade mathematics" (p. 433). In point three, he states that enrichment in eighth grade math is not a good alternative to algebra. His argument here is rhetorical: what is enrichment? Point four emphasizes that algebra is no harder to learn at thirteen than at fourteen. He feels that it is harder to learn algebra as an adult than in high school. He believes "...that a year's difference even at this age would help rather than hinder" (p. 434). In point five, Usiskin believes that placement policies are not logical. He feels that the "rule of thumb" is that the older the student is, the easier it is to get into algebra. His argument is that taking algebra is based on age rather than achievement. Finally, in point six, Usiskin feels that because of the increased demands we put on high school students to complete an academic high school course of study, starting in their eighth grade makes sense.

Prevost (1985) in a cursory study stated that only about half of the students who start algebra in the eighth grade end up in the fifth year of college prep math. He noticed that most of these students dropped out after the sophomore year. Anecdotal statements

revealed most students dropped out of the math program because they were doing better in their other college prep classes but not in math. Prevost noted that 54% of the eighth grade algebra students are male and only 44% are female in the fifth year college prep math. The author believed that only the top 3% to 5% should be accelerated because he found that many of the students in remedial math in college are students who were accelerated in the eighth grade.

"Properly gauging student abilities permits greater accuracy in counseling students" (Mogull, 1972, p. 105). Barbara Flexer (1984) is interested in determining success in placement of students into eighth grade algebra. She started with the premise that accelerating some students into eighth grade algebra proved to be a "stumbling block." Those students were left with the possibility of failure or dropping out of the class. She pointed out that "...previously high-achieving students experience the trauma of failure" (p. 352). In her study of 139 students taking eighth grade algebra, 15 drop out and 7 fail. Flexer determined that a "cutoff point" could be determined that would prevent 73% of the failures but it would also prevent 27% of those students who would be successful. While Flexer is able to see that there will always be failures and dropouts and at best her procedures would only minimize this problem, she is unable to detect who might be discouraged from being accelerated in eighth grade algebra but still pass the class. She is also unable to determine, as no study has been able to do, those students who will continue to take upper level math for the five-year period.

In a similar study attempting to predict success in eighth grade algebra, Belli and Gatewood (1987) may have touched on one area that would explain student success. Based on the assumption from Piaget that individuals go through stages of development

of formal operations, Belli and Gatewood used the Arlin test developed to assess student's current stage of development. It stands to reason that those students chosen to take eighth grade algebra would have higher abstract cognitive development than those who were not chosen to take it. The test given to eighth grade algebra students showed 68% of students in the high concrete stage, 25% in the transitional stage and 7% in the low formal stage. The results for the non-algebra students could explain how many are not ready for algebra in the eighth grade but might be capable by the ninth grade. The Arlin test results of the non-algebra students showed 12% in the high concrete stage, 37% in the transitional stage, and 51% in the low formal stage (Belli & Gatewood, 1987, p. 445).

Elizabeth Useem (1990), a sociologist, begins her study by noting that we do not expose many students to "accelerated" math. The researcher noted that the "sorting" begins at the end of sixth grade when students are selected for pre-algebra. Useem also noted that only 16-17 percent of eighth grade students are accelerated and by the senior year the percentage drops off to about 5 or 6 percent in calculus (p. 24). Interestingly, while she sees this drop for the most talented of the math students, she feels "we need to increase the numbers of students in our advanced mathematics pipeline..." (p. 24). The researcher goes on to look at two systems in the Boston suburbs that are middle to upper middle class and have highly regarded school systems. She noted that one school used a "pump" system to allow more students into the accelerated math curriculum, and compared it with another system that used a "filter" system allowing fewer students access to the accelerated math curriculum. In the "filter" system, Useem noted that one of the criteria is to be in the top 15% of that school on a standardized test, when the

average score for the entire school is over the 95th percentile. This is obviously a case that no one could argue with (1990, p. 26) since the top 15% of such a high scoring school probably means admitting no one under 99th percentile, an extremely stringent cut-off which would exclude many students in the 90 - 98th percentile range. Useem makes another case between two towns in the wealthiest communities in Massachusetts in which the same "filter" vs. "pump" comparison takes place.

In another study, the Bryan Independent School District wanted to look at the effectiveness of the accelerated eighth grade algebra program from 1975 to 1979. The 1975 study showed that of the 42 students who took algebra in the eighth grade only 6 went on to take the fifth year math, calculus. Only 20 students took the first semester of the fourth year math, elementary analysis. In the 1976 study, 46 students started algebra in the eighth grade and only 6 went on to take the fifth year math, calculus. Only 17 students took the fourth year math (Dockweiler, 1981).

Summary

The review of literature showed that middle schools across the nation have begun to offer eighth grade algebra with almost no research determining if they are helping students to get ahead or if they are stifling them before they are capable cognitively or emotionally. The next logical step would be to see if this policy is indeed the answer for eighth graders in the math curriculum. This study is important to this field because it questions the success of accelerating eighth graders in mathematics. It is also important because it adds to the relatively small body of knowledge in an area that is prevalent in middle schools. There is no consensus on this policy. There are very strong opinions and conflicting research, both pro and con, making this an important study. What if the

prevailing trend has negative long-term effects on math students? This is a case study of one school on the effects of eighth graders accelerating their high school college prep math program by offering algebra early.

Methodology

Type of Study

This is a "chart study" which means that the original data were collected for a different purpose. In this case, the data were collected to record the progress of high school students in the class of 1992 at North Harrison High School. In another sense, this study is a longitudinal study of these students over a five-year period starting with the eighth grade and ending with the twelfth grade. The approach utilizes quantitative methods to assess the effectiveness of policy.

The study examines the four-year high school transcripts of those students who started with algebra in the eighth grade at North Harrison High School in the school year 1987-88. Students who took algebra in the eighth grade are followed to see how many years of college preparatory math these students took over the four years they were in high school. (How many of them were in the 5^{th} year of math?) Grade point averages, retention, and low grades in each of the math pipeline subjects are the primary data. In addition, the elementary curriculum is compared (self-pacing vs. traditional) and gender effects are investigated.

Sources of Data

The study tracks the North Harrison High School Graduating class of 1992. This class began the eighth grade in the 1987-88 school year. The population is 179 students (97 males and 82 females). There were 49 students allowed to take algebra in the eighth

grade or 27% of the class. These 49 students represent the target sample for this study; all of them were followed through high school, giving a census of the sub-population. The North Harrison Community School System is located in a stable, lower middle to upper middle class rural setting approximately twenty-five miles west of New Albany, Indiana. Although located in rural setting, few families earn a living by full-time farming. Most parents work in New Albany, Clarksville or Jeffersonville, Indiana or Louisville, Kentucky. There is a combination of professional and working class families. Approximately 50% of the graduating students go on to college, 10% go to post-graduate vocational schools and 20% of the students receive a vocational certificate from the regional vocational school. There is very little movement out of the community and at the present there is some movement into the school system from surrounding communities. In the high school there are currently 10 students living out of the school district that pay tuition. All data were collected from the transcripts of the sub-population over the course of their high school career.

Instrumentation

The instrument is the Records Analysis Protocol (see Appendix A) which details elementary school attended, gender, grades in college prep math, algebra repeaters, and numbers in college prep math. Data are entered from the protocol into SPSS for analysis. (Items 3-6 on the protocol are not utilized in the current study.)

Procedures

The Human Studies Committee (HSC) of the Institutional Review Board at the University of Louisville reviews each study done at the university that involves human subjects. The HSC is a "failsafe" to make sure that every human study done in the

university meets a reasonable expectation for those human subjects studied in regards to: informed consent, confidentiality, risk vs. benefit, meeting federal guidelines (36 standards), and local policy. The Committee gives the researcher approval or disapproval. Approval for this chart study has been obtained.

After HSC approval the protocol guided data transfer from student transcripts. The research questions provide the logic for the quantitative analyses. Results are reported based on descriptive statistics, chi-square, and t tests.

Generalizability

Even though the students being studied in this research came from a rural, primarily middle class, white population, it would be difficult to make generalizations about other schools from this one school. The external validity in this study is weak; however, the literature on this subject suggests that other school systems likewise have a high drop out rate in the math pipeline when students take algebra in the eighth grade. Results are worth expanding and testing at other schools. It may be noteworthy that almost 30% of this class took the accelerated math, which is in excess of the national average of 20 percent.

The internal validity is good because only two students over the course of time transferred out of the school (during the ninth grade) and only one student transferred in (during the ninth grade). During this time period the four teachers remained the same (3 female and 1 male) and didn't change the courses they taught. The stability over time in this study gives unusually strong control against historical and subject attrition threats to validity, a problem in most longitudinal research. The outstanding issues in this study are (a) the difficulty of college prep math; and (b) the differential abilities of those

accelerated students who took algebra as eighth graders vs. the remaining students in the class who were not accelerated. The questions not asked in this study are how would these accelerated students have done over time in the math pipeline if they had started taking algebra in the ninth grade? And how much of the high attrition rate for these students also occurs in the "regular" or non-accelerated groups (73% of the cohort)? These issues pertain to mathematics success generally, are affected by differences in ability, and could not be addressed, given the data available.

Results

The data collected for this study directly address the research questions. After compiling the results of the protocol, the authors decided to eliminate three of the 49 original participants from the results because they transferred to other school systems leaving a question about the effects of the policy on their math progress. This leaves 46 participants to be analyzed. The research questions are repeated for the convenience of the reader.

Research Question #1

To what degree do students in eighth grade algebra progress through upper level math after early entry?

a. How many students complete each of the subsequent higher-level math courses up to and through the fifth year math?

b. What is the grade point average (GPA) in each of these math classes?

Table 1 gives descriptive statistics for number and percent of students, mean GPA, and standard deviation, broken out for the entire group and by elementary school of origin. The first subquestion addresses attrition from the math curriculum. For Algebra

II, 42 (91%) of the students are still in the pipeline. A large number of students exit the pipeline after Algebra II where enrollment falls to 26 for fall semester 11th grade trigonometry, 57% of the original 46. Finally, only 14 of 46 or 30% of those accelerated students who stayed at NHHS went into the fifth year of college prep math.

The second subsection examines grade point averages. The total GPAs were lower in Geometry (2.1 overall) and in statistics (2.0); other courses ranged from 2.5 for Trigonometry to 2.9 for Precalculus. The overall trend suggests declining GPAs throughout the sequence of courses. The two exceptions to this are Geometry (9th) and Precalculus (12th). By the time students reached the last year, however, only 14 remained so the higher GPA there suggests survival of the best math students.

Research Question #2

To what extent do some of these accelerated students have negative experiences?

a. How many, and when, do students drop out of the math curriculum?
b. How many students repeat algebra?
c. How many students receive low grades--C or less than C--in each of the math pipeline courses?

Table 2 provides the answers for Research Question 2, Subsection 2.a., which is essentially the converse of Research Question 1, i.e., when do students fall by the wayside rather than how long do they persist. The largest number of "exiters" was after Algebra II which is offered in the 10th grade: 16 (35%) drop out of math between sophomore and junior year. The junior year has two separate semester courses, Trig and Statistics, but only 3 students exited math after Trigonometry. An additional 9 (20%) left the pipeline prior to senior precalculus. Clearly, math dropouts are a problem in this case

study.

Those repeating Algebra I in the ninth grade were 19 of the remaining 46 accelerated math students or 41% of the group (Subsection 2.b.).

Finally, for Subsection 2.c., low grades of "C" or less than "C," the latter are arranged so that the low grade is counted only once for a given student if he/she received that grade for the Fall semester or Spring semester or both. There were 42 students who earned a grade lower than C, 30 of these in Geometry, a ninth grade subject. The number of students who received a C grade in the previous course didn't appear to deter students from taking the next course in the pipeline even though the number of students in the pipeline decreases after Geometry. The number of students receiving a C was substantial, particularly early in the pipeline: Algebra I (17/46) 37%; Algebra I, 9th grade repeat (10/19) 53%; Geometry (29/46) 63%; and Algebra II (27/46) 59%. For two courses, the combined "C" plus "Below C" grades were shockingly high: Geometry (35/46) 76% and Algebra II (26/42) 62%.

Research Question #3

Does the elementary school math curriculum (self-pacing vs. traditional) affect the math profile for eighth grade Algebra and subsequent math courses?

a. Number in each course?

b. GPA?

c. Math dropouts and when?

d. Repeat algebra?

e. Less than a "C" in math pipeline courses?

Answering this research question involves a series of comparisons among the

three sources of students in the accelerated Algebra I (8^{th}) program: Morgan Elementary, traditional math curriculum; North Harrison Elementary, self-pacing math curriculum; Transfer into North Harrison High School, elementary math curriculum unknown. Since the focus of the study was to examine the two instructional approaches for teaching elementary mathematics--traditional versus self-pacing--the transfer students into the North Harrison High School math pipeline are not examined. The comparisons for each subsection of the research question (a-e) are calculated for each of the courses in the math pipeline. Analyses for subsections a, c-e involve frequency counts and percentages; Chi-squares are computed for these. For GPA (subsection b), an independent samples t-test, two-tailed, is utilized. All values are taken from Tables 1 and 2. Each subsection is addressed in turn.

Subsection 3.a. Number in each course?

For this comparison, the issue is whether the traditional math instruction approach of Morgan Elementary or the self-pacing approach at North Harrison Elementary has an effect on the number of students who continue through the subsequent math pipeline courses. Chi-square values are computed for each course. For Algebra I (8^{th}), the chi-square is based on a one row comparison (ME vs. NH); all the remaining courses are computed as a two by two contingency table with the enrollment for that particular class arrayed in each instance against the enrollment for the original 8^{th} grade Algebra I cohort, crossed by ME versus NH. These chi-square calculations are displayed in Table 3. In no instance was the chi-square significant; the largest chi-square was only 1.0, for the original distribution in Algebra I (8^{th}). The effect in subsequent courses approaches 0 in all instances, the highest value being .124 in Precalculus. Thus, the instructional

approach has no effect on progress through (retention in) the math pipeline in this case study.

Subsection 3.b. GPA?

Table 4 shows the independent samples t test comparisons for Morgan Elementary (traditional instruction) versus North Harrison Elementary (self-pacing). Only Algebra I (8^{th}) reached significance in terms of mean difference with the advantage to the self-pacing approach at North Harrison. Any difference that could have been due to the instructional approach was apparently negated by the passage of time and classes taught by a common instructor from 7^{th} grade pre-algebra onward. Even the source of difference for 8^{th} grade Algebra I is uncertain because selection cannot be ruled out as a contributing factor. There could be differences in the students at the outset of the advanced math track.

Subsection 3.c. Math dropouts and when?

This subsection addresses the issue of retention. How many students stop taking math courses before they get to precalculus and when do they exit the pipeline? Answering this question does not require any new calculations because this subsection is actually the converse of Subsection 3.a., which gives frequency counts for how many students remain in each course. Table 3 demonstrated that there were no differences between the two instructional approaches--traditional versus self-pacing--with respect to how many students stayed the course throughout the pipeline. Logically, there can be no difference, therefore, for when students leave the pipeline as affected by the instructional approach in the elementary school that they attended. Thus, Subsection 3.a. and Subsection 3.c. are consistent: instructional approach has no effect on retention in the

math pipeline or its converse, dropping out.

Subsection 3.d. Repeat Algebra?

For this subsection, the question is whether the instructional approach in elementary school, traditional at Morgan Elementary or self-pacing at North Harrison Elementary, affects having to repeat algebra in ninth grade. Again this subsection requires no new calculations. The chi-square computation in Table 3 for Algebra I (9^{th}) was non-significant, χ^2 (1, N = 59) = .467, $p > .05$. Subsection 3.d. revisits the data from Subsection 3.a. as a separate issue because having to repeat a class is such an important indicator of failure in education, both cognitively and emotionally. That stigma remains for these 19 (41%) Algebra I repeaters (17 from ME and NH plus two transfer students--see Table 1) even though the elementary school instructional approach had no effect on this failure.

Subsection 3.e. Less than a "C" in math pipeline courses?

This subsection addresses whether students who received a "D" or "F" in any of the math pipelines courses could be connected to the elementary school instructional approach--traditional at Morgan Elementary or self-pacing at North Harrison. The data are tabulated so that the student who receives a D or F in either semester or both semesters is counted once. The comparison involves a two by two contingency table, ME vs. NH as one factor; enrollment in each course versus number of students with a D, F, or both in each course as the second factor. Chi-square results are reported in Table 5. The results indicate elementary school instructional approach did not reach significance for any of the pipeline courses. Again, there are no lasting effects from the two different instructional approaches in this study.

Research Question #4

To what extent does gender affect student success in early entry to college preparatory mathematics, for factors a-e listed under question #3?

Research Question #4 addresses the effect of gender for these early algebra students, examined throughout the math pipeline courses, for the same five subsections as in Research Question #3. Descriptive statistics are reported first. Then a series of calculations are performed to determine if gender has an effect on distributions. Again for Subsections a, c-e, chi-square is utilized while a t test is used for Subsection b.

Descriptive Statistics

Table 6 gives descriptive statistics (frequency, percent, mean GPA, standard deviation) for all courses in the math pipeline, divided by gender. Two trends stand out. First, girls outnumber boys (67% to 33%) for the original 8th grade algebra and that advantage is maintained through the pipeline. The one exception is Algebra I (9th) where a similar number of both sexes had to repeat algebra. The second trend is that the girls' GPA is generally higher. This is true except for the original 8th grade class where the boys were slightly higher. Whether these differences are more than random fluctuation is examined in the following subsections.

Subsection 4.a. Number in each course?

The actual number and percentages by gender are reported in Table 6 and discussed under Descriptive Statistics, immediately above. To determine whether these differences (more girls than boys) were significant, a series of chi-squares are computed. Algebra I (8th) required a one factor analysis. However, because the effects over time through the pipeline are involved for all subsequent courses, and because the original

distribution in 8th grade is uneven, a two factor chi-square is utilized: gender (boys vs. girls) and enrollment continuity (Algebra I, 8th frequency vs. pipeline frequency) calculated separately for each course. The data are derived from Table 6. Results of the chi-squares are given in Table 7. For Algebra I (8th), the original two to one proportion (31-15) in favor of girls is statistically significant. None of the remaining chi-squares is significant.

However, this result indicates that gender has no continuing effect on the progress through the pipeline, given the original disproportion in favor of girls in Algebra I (8th). Inspection of Table 6 frequency counts clearly shows that females maintain their enrollment advantage throughout the pipeline (except for Algebra I, 9th which is an aberration--only repeaters). The chi-square calculations, however, did not examine this enrollment advantage for females for statistical significance, instead examining any changes in proportion after the eighth grade year, i.e., effects of gender on enrollment continuity. This lack of change after the eighth grade is the meaning of the non-significant results.

Subsection 4.b. GPA?

For this section, GPA is compared by gender in each of the math pipeline courses. Based on the means and standard deviations reported in Table 6, two-tailed independent samples t tests were calculated. These results appear in Table 8. Only Trigonometry in the fall of the junior year reached statistical significance, with females outperforming males ($\underline{M}$ = 2.76 vs. $\underline{M}$ = 2.0). For all courses except Precalculus, Levene's Test for Equality of Variance was not significant and computations are based on equal variances formula. For Precalculus, the calculations are based on assumptions that variances are

not equal.

Subsection 4.c. Math dropouts and when?

As in Subsection 3.c., math dropouts are the flip side of continuing enrollment. Here the question is whether gender affects this rate of attrition. Table 7 shows the chi-square calculations for enrollment through the math pipeline, based on gender. While the initial distribution in eighth grade was significantly skewed in favor of females (31 to 15, from Table 6), none of the remaining courses had a significant chi-square. Thus after the initial unbalanced selection into the pipeline back in seventh grade for pre-algebra, males and females fall by the wayside at approximately the same rate.

Subsection 4.d. Repeat algebra?

Likewise, Subsection 4.d. requires no new calculations. As in Subsection 3.d., repeating algebra is revisited because of its importance as an indicator of failure, here examined by gender differences. From Table 7, the calculation for Algebra I (9^{th}) is χ^2 $(1, \underline{N} = 65) = 3.67$, $p > .05$; although a greater proportion of males had to repeat this course (from Table 6), the result was not statistically significant.

Subsection 4.e. Less than a "C" in math pipeline classes?

Table 9 presents the chi-square calculations for low grades (D or F for one or the other or both semesters) by gender. The contingency tables were constructed from Table 6 and the raw data. Across the math pipeline only the distribution in Trigonometry was statistically significant. Consistent with the other data in this case study, the contingency matrix shows that females out-performed males (with almost twice as many enrolled, girls had no low grades to 3 for boys). Gender proportions in the other courses followed the original eighth grade enrollment closely. By Pre-calculus, there were no grades

below C.

Discussion

Analysis

This research follows the pattern of other studies on accelerating precocious math students in eighth grade algebra. The case study started with 49 students in eighth grade algebra (3 students subsequently transferred out of North Harrison High School) and ended with 14 (30%) in fifth year math (Precalculus). Nineteen students chose to retake Algebra I in the ninth grade. All of these students had high IQ's and high abstract reasoning skills (these data not shown), were good students in the pre-algebra class offered in the seventh grade, and received a recommendation from the seventh grade teacher just like the ones who continued successfully directly to Geometry. (The fact that there does not appear to be a difference between the "retakers" and "succeeders" clearly puts pressure on the sixth grade math teacher to recommend versus not recommend the student for pre-algebra.) The policy was a good one for the 14 students who stayed in the pipeline, but was it a good policy for the other 32 students who dropped out of the pipeline?

Ultimately, this question cannot be answered without accounting for the rate of dropout from the math pipeline for students who begin the math prep sequence with Algebra I as a ninth grader. But since few American students now wait until ninth grade to take Algebra I, this is a difficult comparison to make. However, the current study does provide some useful information for this question. For one instance, three of the 19 who retook algebra in the ninth grade completed the pipeline by "doubling up" with Geometry and Algebra II in the 10^{th} grade, showing that "doubling up" route can be a viable path.

were not as bad in this regard, but by then attrition had taken its toll and only the better math students remained.

These are devastating numbers for identified precocious students who are doing well in English, science and foreign language. Because they are selected as the "best" students in their cohort, presumably they would be the most likely to complete the math pipeline. This study certainly does not provide strong evidence to support early algebra taking.

But, as indicated above, part of the problem is exiting from the math pipeline, period. While the loss of accelerated algebra takers is tragic, American students generally do not complete the full math pipeline. Thus, it remains uncertain as to whether the early entry into college prep as an eighth grader compounds the problem, or is simply subsumed by American's poor record of retention in advanced high school math courses.

On a more encouraging note, the current study disconfirms the much heralded problem of females participating in math and science at lower rates. The study also counteracts the "commonplace" knowledge that females are not doing as well when enrolled, as compared to males. In this analysis, girls participated at higher levels and did as well or better as boys throughout. Perhaps the extensive attention to this issue throughout the 1980s and 1990s has produced greater awareness of the problem and a climate in which girls are no longer discouraged from these "hard" scientific areas.

With regard to the instructional approach utilized in the upper elementary school, this study revealed no lasting effects. The traditional approach of the sixth graders at Morgan Elementary and the self-pacing, mastery strategy at North Harrison Elementary

(Since 1992, North Harrison, like most high schools, now offers calculus instead of precalculus as the final class in the math pipeline. In order to complete the full sequence to calculus, students who take Algebra I in the eighth grade would have to "double up" to complete the new sequence; a student who began with Algebra in ninth grade would now have to "double up" twice.)

Four students dropped out of the pipeline after Geometry and 16 students dropped out of the pipeline after Algebra II. This is similar to exiters in other studies of accelerated math students. Prevost (1984) stated in his cursory study of accelerating eighth graders in math that most of the students that exit the pipeline exit after their sophomore year. Accelerated math students take Algebra II in their sophomore year. Prevost's observation is confirmed in this study.

This longitudinal study of accelerating precocious eighth grade math students over the five years of pipeline math is similar to the Kulik and Kulik (1984) study, which revealed that 24% of those students who started with eighth grade algebra finished the pipeline. The Dockweiler (1984) study showed that in 1975 six of the 42 eighth grade students who were accelerated completed the fifth year of high school math and that in 1976, six of 47 students accelerated eighth graders completed the fifth year of high school math. The completion rate for NHHS was 32%.

Other data from this study suggest similar problems. Grade point averages for the math pipeline courses were generally low, and particularly so for statistics (2.0) and Geometry (2.1). The proportion of low grades, concomitment with low GPA, was also disturbing, particularly early in the pipeline: 37 percent received a D or F in one semester or the other or both in Geometry (9^{th}), 20 percent in Algebra II (10^{th}). Subsequent classes

apparently makes no difference over time. Once the students from the two elementary school reach middle school, they have common courses starting with pre-algebra in seventh grade. These common experiences apparently negate any differences that might exist back in sixth grade.

Recommendations

The next step in research on accelerating eighth graders in the math pipeline would be to study the exiting of precocious math students who start the pipeline in the ninth grade. If this proposed study were to show a similar dropout/completion rate, then the policy of accelerating eighth graders would not be necessarily harmful. It would validate that students drop out of the pipeline regardless of acceleration. If this proposed study were to produce success in terms of retention in the pipeline, then educators would need to examine the current practice of beginning the algebra sequence early. This may be difficult because almost every middle school and junior high in the United States now offers algebra in the eighth grade.

Given the difficulty of doing a controlled "starting eighth grade" vs. "starting ninth grade" study (not only because most junior high schools now begin the college prep pipeline but also because a random or matched assignment of some bright math students to begin early and some to delay a year until high school is clearly not feasible), there are a number of other strategies to address the issue.

One significant study would be to look at the time eighth grade students spend in class compared to high school students. In the North Harrison school system, each period is 42 minutes long in middle school and 52 minutes long in high school. Over a school year of 180 days, an eighth grader misses 1800 minutes or 30 hours of instruction.

Middle school may also have more convocations and field trips adding to a time loss of classroom instruction. Does this difference in allocated time generalize across schools? And what is the effect here of block scheduling? Perhaps it would be timely to revisit the allocated instructional time effects.

Another study might compare instruction of middle school algebra teachers versus the instruction from high school algebra teachers. Middle school often has a different approach to students than elementary and high school. Part of this focus would be certification and depth of math training for middle school vs. high school algebra teachers. The second aspect would be actual instructional practices, which would require extended ethnographic observations. On both aspects, there could well be differences between middle and high school, but the current literature is basically silent on these issues.

Until such time as better information on these problems is available, the authors believe that this policy should be adjusted to identify better those early algebra takers who are likely to complete the pipeline. This may require longitudinal analysis of individual level data on who "succeeded" and who "exited" from the pipeline throughout high school. Aptitude score, pre-algebra grades, abstract reasoning abilities, and teacher recommendations may be among factors that could lead to better identification of candidates for early or delayed entry into the math pipeline. Again, the literature on this is minimal at best, but confer Belli and Gatewood's (1987) work here.

This study had a side issue that made it unique from other studies. The math faculty at NHHS was female. The female math pipeline students did as well or better than male math pipeline students did. With all the current discussion that female students

learn math better working as a coherent group, the females in this study outnumbered the males in each pipeline course. Females in this study also had a higher mean GPA than males. The authors believe an interesting study would compare how well female students achieve when the instruction comes from a female math teacher versus a male math teacher. Similarly, does a predominantly female class provide a "safer," more accepting climate for girls than one in which the male-female ratio is even or majority boys?

A related qualitative study needs to be done to ask the students themselves if they feel that accelerating in the math pipeline was beneficial to them or not. This type of study should also include inquiring about pressures on the student at the end of the sixth grade to accelerate to pre-algebra in the seventh grade and the pressure to repeat algebra.

Obviously, one last recommendation for further research would be to conduct a similar study to the one at NHHS using a larger population, and with a more recent cohort in which the end of the pipeline is calculus rather than precalculus.

Conclusions

This longitudinal "chart study" indicated that the policy of accelerating students in math at NHMS has a negative impact for many of those students: repeating Algebra I in the ninth grade (39%), dropping out of the pipeline (69%), and experiencing poor grades in the pipeline (59%). The mean GPAs in Geometry (2.1) and Statistics (2.0) were particularly low, and the trend throughout was not much better. The school district accelerated 49 students in eighth grade (46 graduated from the district). Of these 46, only 14 students (32%) could finish five years of math. Is it worth screening and accelerating students as early as the eighth grade if so few end up in fifth year math? Is it possible to be sure of the accuracy of the screening process when the process begins in the sixth

grade? Would delaying the start for the math pipeline until the ninth grade result in a more positive experience for these accelerated math students?

Previous research in this area indicated similar or even more negative results than at NHMS, even by a sociologist, Useem (1990), who investigated accelerating math in prestigious public schools in Massachusetts. Accurately screening students in the sixth grade is difficult at best, and perhaps beyond what is currently possible, given tools that are now available. Possible solutions under current curricular/instructional conditions include limiting acceleration to only the few truly precocious math students in the eighth grade, having a high school teacher teach them, preferably in the high school for a full high school period, or simply allowing everyone to start with Algebra I in the ninth grade and "double up" somewhere in the pipeline.

Yet, this entire study examined success in the pipeline under current/traditional math instruction. There is another possibility: that it is not the acceleration that is problematic, but rather traditional math instruction. Many researchers are exploring constructivist approaches to math education, with the expectation that these methods will increase retention in the pipeline, level of achievement and understanding and even interest in math itself. The current study cannot speak to this issue. It may be noteworthy, however, that the current literature in math education, for example, is much more focused on this issue (curricular/instructional reform based on constructivist approaches) than on the consequences of accelerated algebra taking, as raised by this study.

More questions need to be answered and more research is required to determine if accelerating students in the math pipeline is an appropriate policy. Perhaps the one

conclusion that all sides can agree to is that the current situation regarding long term success in the math pipeline in American schools is simply not acceptable.

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Table 1

Descriptive Statistics for Math Classes in Pipeline

	Frequency								Mean GPA							
	ME[a]		NH[b]		TR[c]		Total		ME		NH		TR		Total	
Course	N	(%)	N	(%)	N	(%)	N	(%)	M	SD	M	SD	M	SD	M	SD
Algebra I (8th)	18	(39)	24	(52)	4	(9)	46	(100)	2.7	.59	2.9	.60	3.0	.57	2.9	.57
Algebra I (9th)[d]	19	(20)	8	(17)	2	(4)	19	(41)	2.6	.78	2.5	1.11	3.0	.46	2.6	.00
Geometry (9th)	18	(39)	24	(52)	4	(9)	46	(100)	2.1	.86	2.1	.89	1.9	.80	2.1	.75
Algebra II (10th)	16	(35)	22	(48)	4	(9)	42	(91)	2.6	.95	2.7	1.13	2.0	.79	2.5	.82
Trig (11th F)	11	(24)	14	(30)	1	(2)	26	(57)	2.7	.81	2.4	.70	2.0	1.01	2.4	.71
Statistics (11th S)	9	(20)	13	(28)	1	(2)	23	(50)	2.0	1.06	2.2	1.20	2.0	1.01	2.0	.71
Precalculus (12th)	5	(11)	8	(17)	1	(2)	14	(30)	3.0	.98	3.0	1.14	1.5	.76	2.8	.98

Note. The order of classes is given for the accelerated college prep pipeline; students taking algebra I for the first time in the 9th grade would only get through Trigonometry and Statistics, unless they "doubled up."

[a]ME represents Morgan Elementary, which used the traditional math curriculum.

[b]NH represents North Harrison Elementary, which used the self-pacing math curriculum.

[c]TR represents transferred into NHHS and stayed in the pipeline--elementary math curriculum unknown.

[d]Algebra students who repeat Algebra I in the ninth grade.

Table 2

Students' Rate of Exit from and Low Grades in Math Pipeline

Course	Low grades C (%)				Poor grades below C (%)				N (%) dropping from pipeline (Exiters)			
	ME[a]	NH[b]	TR[c]	Total	ME	NH	TR	Total	ME	NH	TR	Total
Algebra I (8^{th})	9 (19%)	7 (15%)	1 (2%)	17 (37%)	2 (4%)	1 (2%)	--	3 (7%)				
Algebra I (9^{th})[d]	4 (9%)	6 (13%)	--	10 (22%)	2 (4%)	1 (2%)	--	3 (7%)				
Geometry (9^{th})	11 (23%)	15 (28%)	3 (7%)	29 (63%)	6 (13%)	7 (15%)	4 (9%)	19 (41%)	2 (4%)	2 (4%)	--	4 (9%)
Algebra II (10^{th})	9 (19%)	16 (35%)	2 (4%)	27 (59%)	1 (2%)	3 (9%)	3 (7%)	7 (15%)	5 (11%)	8 (17%)	3 (9%)	16 (35%)
Trig (11^{th} F)	3 (6%)	5 (11%)	1 (2%)	8 (17%)	1 (2%)	2 (2%)	--	4 (9%)	5 (11%)	2 (4%)	3 (9%)	10 (22%)
Statistics (11^{th} S)	3 (6%)	3 (9%)	0 (0%)	6 (13%)	4 (9%)	4 (7%)	--	9 (19%)	5 (11%)	5 (11%)	1 (2%)	11 (22%)
Precalculus (12^{th})	1 (2%)	2 (4%)	1 (2%)	4 (9%)	1 (2%)	--	1 (2%)	2 (4%)	--	--	--	--

Note. Exiters are those math students who drop out of the math pipeline before completion.

[a]ME represents Morgan Elementary, which used the traditional math curriculum.

[b]NH represents North Harrison Elementary, which used the self-pacing math curriculum.

[c]TR represents transferred into NHHS and stayed in the pipeline--elementary math curriculum unknown.

[d]Algebra I (9^{th}) represents students who repeated Algebra I after a less than satisfactory experience in the 8^{th} grade.

Table 3

Chi-square Calculations for Frequency in Math Pipeline Courses by Elementary School Instructional Approach

Course	Chi-square calculations
Algebra I (8^{th})	χ^2 (1, N = 41) = .60, p > .05
Algebra I (9^{th})	χ^2 (1, N = 57) = .105, p > .05
Geometry (9^{th})	χ^2 (1, N = 82) = 0, p > .05
Algebra II (10^{th})	χ^2 (1, N = 78) = .032, p > .05
Trigonometry (11^{th} F)	χ^2 (1, N = 67) = .156, p > .05
Statistics (11^{th} S)	χ^2 (1, N = 62) = .007, p > .05
Precalculus (12^{th})	χ^2 (1, N = 54) = .02, p > .05

Note. For Algebra I (8^{th}) a one factor chi-square was computed (ME vs. NH); for all subsequent courses, a 2 by 2 contingency table was constructed utilizing Factor 1, elementary instructional approach (ME vs. NH); and Factor 2 (enrollment continuity with Algebra I, 8^{th} frequency vs. enrollment in course compared). All frequencies are taken from Table 1.

Table 4

Independent Samples t test for Mean GPA in Math Pipeline Courses by Elementary School Instructional Approach

Course	t	df	Sign. (2-tailed)
Algebra I (8^{th})	-2.073	40	.045*
Algebra I (9^{th})	.268	15	.792
Geometry (9^{th})	.183	40	.855
Algebra II (10^{th})	-.336	36	.739
Trigonometry (11^{th} F)	.952	23	.351
Statistics (11^{th} S)	-.483	20	.635
Precalculus (12^{th})	.000	11	1.000

Note. Group 1 was Morgan Elementary (traditional instruction); Group 2 was North Harrison Elementary (self-pacing instruction); means and standard deviations for the two schools are reported in Table 1 and utilized for these calculations.
*p < .05.

Table 5

Chi-square Calculations for Grades Below C in Math Pipeline Courses by Elementary School Instructional Approach

Course	Chi-square calculations
Algebra I (8^{th})	χ^2 (1, N = 44) = 2.349, p > .05
Algebra I (9^{th})	χ^2 (1, N = 20) = 2.353, p > .05
Geometry (9^{th})	χ^2 (1, N = 56) = .857, p > .05
Algebra II (10^{th})	χ^2 (1, N = 45) = .002, p > .05
Trigonometry (11^{th} F)	χ^2 (1, N = 27) = .027, p > .05
Statistics (11^{th} S)	χ^2 (1, N = 28) = .159, p > .05
Precalculus (12^{th})	No low grades

Note. All comparisons involved a 2 by 2 contingency table; the two factors were elementary math instructional approach (ME vs. NHE) and proportion of low grades (enrollment in each course vs. frequency for a D or F for one semester or the other or both for that course). Enrollment taken from Table 1; low grades from Table 2.

Table 6

Descriptive Statistics for Math Pipeline Courses by Gender

	Total			Female				Male			
Course	N	GPA	SD	N	(%)	GPA	SD	N	(%)	GPA	SD
Algebra I (8^{th})	46	2.89	.59	31	(67)	2.87	.61	15	(33)	2.93	.56
Algebra I (9^{th})	19	2.61	.79	11	(24)	2.77	.56	8	(17)	2.38	1.03
Geometry (9^{th})	46	2.07	.83	31	(67)	2.13	.75	15	(33)	1.93	.98
Algebra II (10^{th})	42	2.56	.88	30	(65)	2.62	.87	12	(26)	2.42	.93
Trig (11^{th} F)	26	2.50	.95	17	(37)	2.76	.75	9	(20)	2.00	1.12
Statistics (11^{th} S)	24	2.13	1.0	16	(35)	2.25	1.13	7	(15)	1.86	.90
Precalculus (12^{th})	14	2.89	.98	11	(24)	2.91	1.11	3	(7)	2.83	.29

Note. Algebra I (9^{th}) represents students who repeated Algebra I because of unsatisfactory experience; GPA is grade point average; all percentages are calculated on the original enrollment in the eighth grade.

Table 7

Chi-square Calculations for Gender Enrollment in Math Pipeline Courses

Course	Chi-square calculations
Algebra I (8^{th})	χ^2 (1, N = 46) = 5.56 p < .05
Algebra I (9^{th})	χ^2 (1, N = 65) = 3.67, p > .05
Geometry (9^{th})	χ^2 (1, N = 92) = .000, p > .05
Algebra II (10^{th})	χ^2 (1, N = 88) = .177, p > .05
Trigonometry (11^{th} F)	χ^2 (1, N = 72) = .062, p > .05
Statistics (11^{th} S)	χ^2 (1, N = 69) = .111, p > .05
Precalculus (12^{th})	χ^2 (1, N = 60) = .543, p > .05

Note. For Algebra I (8^{th}) a one factor chi-square was computed (gender); for all subsequent courses, a 2 by 2 contingency table was constructed utilizing: Factor 1 (gender); Factor 2 (enrollment continuity with Algebra I, 8^{th} frequency vs. enrollment in course compared). All frequencies are taken from Table 6.

Table 8

Independent Samples t test[a] for Mean GPA by Gender Across Math Pipeline Courses

Course	t	df	Sign. (2-tailed)
Algebra I (8^{th})	.334	44	.749
Algebra I (9^{th})	-1.086	17	.293
Geometry (9^{th})	-.748	44	.458
Algebra II (10^{th})	-.662	40	.512
Trigonometry (11^{th} F)	-2.082	24	.048*
Statistics (11^{th} S)	-.813	21	.425
Precalculus (12^{th})	-.202	11.92	.843

Note. Group 1 is Male; Group 2 is Female; means and standard deviations for GPA are taken from Table 6.

[a]All t tests except for Precalculus utilize calculations for equal variances. For Precalculus, Levene's Test for Equality of Variances was significant (p = .044) and calculations are for equal variances not assumed.

*p < .05.

Table 9

Chi-square Calculations for Grades Below C in Math Pipeline Courses by Gender

Course	Chi-square calculations
Algebra I (8^{th})	$\chi^2(1, N = 49) = 1.173, p > .05$
Algebra I (9^{th})	$\chi^2(1, N = 22) = .629, p > .05$
Geometry (9^{th})	$\chi^2(1, N = 65) = .630, p > .05$
Algebra II (10^{th})	$\chi^2(1, N = 49) = .577, p > .05$
Trigonometry (11^{th} F)	$\chi^2(1, N = 29) = 7.74, p < .05$
Statistics (11^{th} S)	$\chi^2(1, N = 31) = .136, p > .05$
Precalculus (12^{th})	No low grades

Note. All comparisons involved a 2 by 2 contingency table: Factor 1 is Gender; Factor 2 is proportion of low grades (enrollment in each course vs. frequency for a D or F for one semester or the other or both for that course). Enrollment taken from Table 6; Low grades tabulated from raw data.

APPENDIX

Records Analysis Protocol

1. Gender 1 – Male
   2 – Female

2. Elementary School Attended NHE – North Harrison Elementary
   ME – Morgan Elementary
   TR – Transfer In

3. Cognitive Skills Index (IQ)_____

4. Differential Aptitude Test for Abstract Reasoning_____

5. Math Application Score on California Achievement Test_____

6. 7th Grade Math Grade (4.0 scale for both semesters)_____

7. 8th grade Algebra Grade (4.0 scale for both semesters)_____

8. Repeat Algebra 8 in the ninth grade 1 – Yes
   2 – No

9. Highest College Prep Math Completed (Circle)

1	2	3	4	5	6
Algebra	Geometry	Algebra II	*Trigonometry	*Statistics	Pre-calculus

10. Grade Average in Each of the College Prep Math (4.0 scale for both semesters)

    Algebra (if repeated)_____

    Geometry_____

    Algebra II_____

    *Trigonometry_____/Statistics_____

    Precalculus_____

    *Trigonometry is offered in the fall semester and Statistics is offered in the spring semester.